

The fastest spinning Galactic pulsar

Cees Bassa

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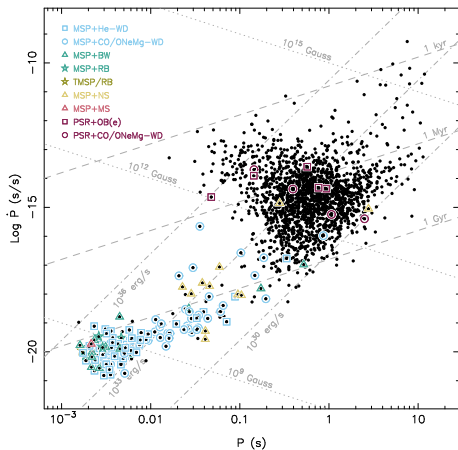
ASTRON

February 8, 2017

Why search for millisecond pulsars?

MSPs can be used to understand:

- the neutron star equation-of-state
- tests of General Relativity
- binary evolution
- the physics of accretion
- the emission mechanism



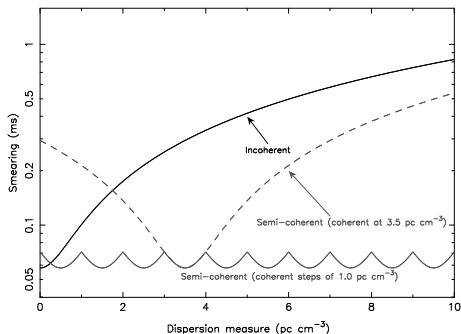
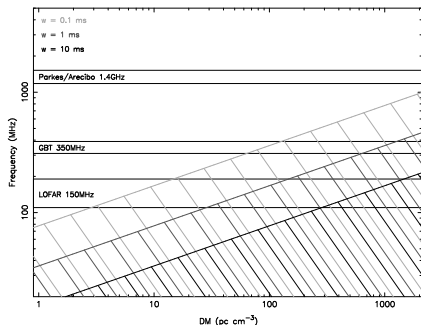
Searching for MSPs with LOFAR

Advantages:

- Steep radio spectra → bright at low frequencies
- Unexplored parameter space

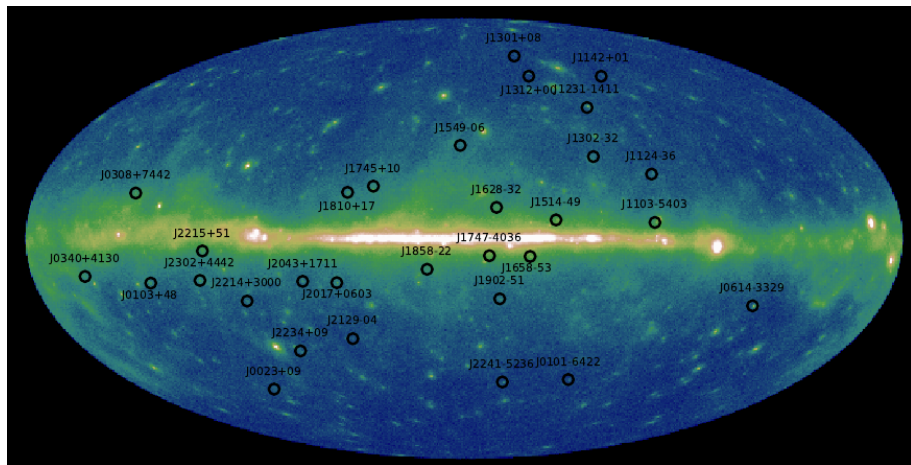
Disadvantages:

- Interstellar medium (dispersion & scattering)
- High time resolution/data rates required



Semi-coherent dedispersion ([Bassa et al. 2017](#))

Targeted surveys of *Fermi* γ -ray sources



(Scott Ransom)

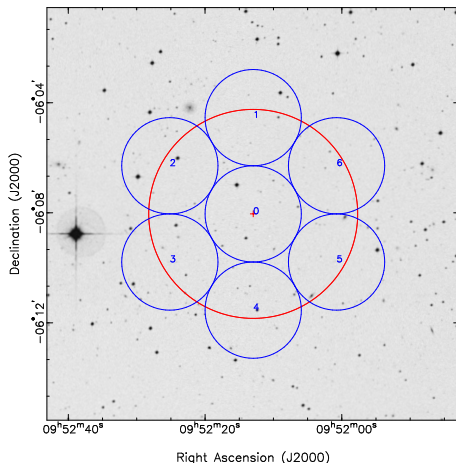
LC7 LOFAR HBA Survey of *Fermi* γ -ray sources

Observational setup:

- record complex voltage data
- 7 tied-array beams
- 21 core stations
- 200 subbands (115 to 155 MHz)
- target 23 MSP-like γ -ray sources
- 2 \times 20 min per target

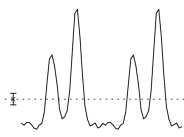
Processing:

- copy from CEP4 to DRAGNET
- redigitize from 32 bit to 8 bit
- coherent/incoherent dedispersion
- frequency-domain acceleration searches



Fastest Galactic MSP!

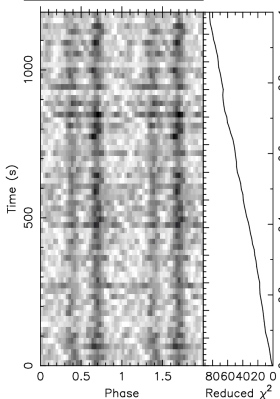
2 Pulses of Best Profile



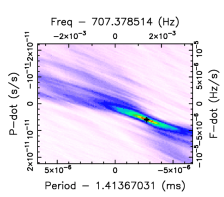
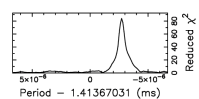
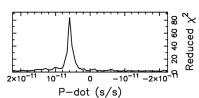
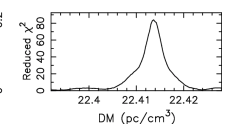
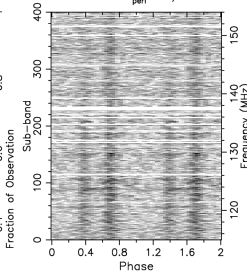
Candidate: ACCEL_Cand_1
 Telescope: LOFAR
 Epoch_{topo} = 57747.12430555555
 Epoch_{bary} = N/A
 T_{sample} = 8.192e-05
 Data Folded = 14592000
 Data Avg = 7.636e+04
 Data StdDev = 430.3
 Profile Bins = 32
 Profile Avg = 3.482e+10
 Profile StdDev = 2.906e+05

Search Information

RA_{J2000} = 09:52:12.9600 DEC_{J2000} = -06:08:02.4000
 Best Fit Parameters
 DOF_{eff} = 13.72 χ^2_{red} = 83.993 P(Noise) \sim 0 (49.4 σ)
 Dispersion Measure (DM; pc/cm³) = 22.414
 P_{topo} (ms) = 1.413667588(19) P_{bary} (ms) = N/A
 P_{topo} (s/s) = 5.94(12)x10⁻¹² P_{bary} (s/s) = N/A
 P_{topo} (s/s²) = 0.0(6.6)x10⁻¹⁶ P_{bary} (s/s²) = N/A
 Binary Parameters
 P_{orb} (s) = N/A e = N/A
 a₁sin(i)/c (s) = N/A ω (rad) = N/A
 T_{peri} = N/A



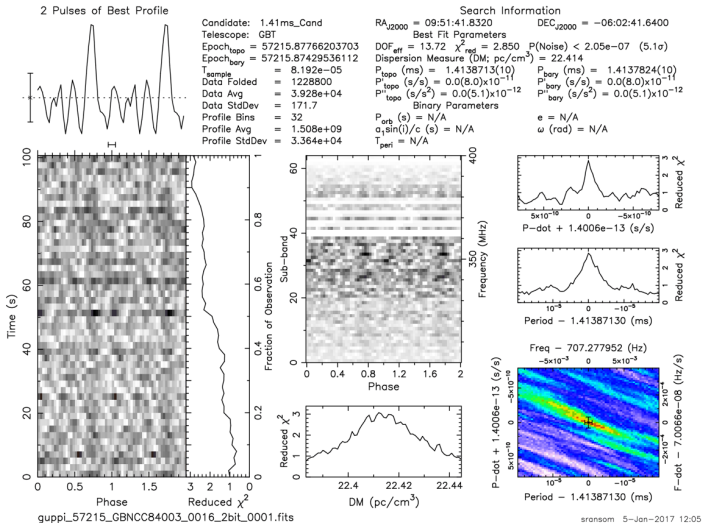
L563213_SAP000_B005_cDM022.50.fil



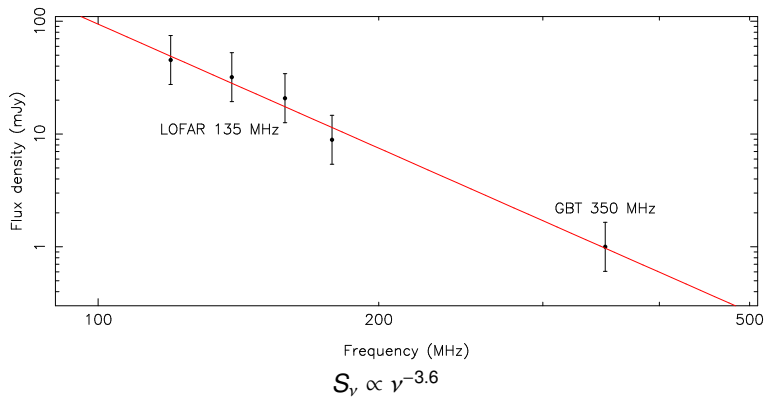
Fastest Galactic MSP!

- **Ter 5ad:** 716 Hz (2005; in globular cluster)
- **J0952–0607:** 707 Hz (2017)
- **B1937+21:** 641 Hz (1982)
- **B1957+20:** 622 Hz (1988)
- **J1747–4036:** 606 Hz (2009)
- **J1810+1744:** 601 Hz (2009)

GBT 350 MHz detection



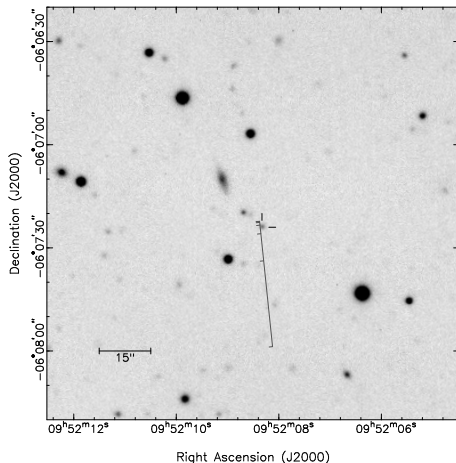
Spectrum



System properties

PSR J0952–0607:

- 707 Hz spin frequency!
- DM of 22.4 pc cm^{-3}
- Binary system (6.42 hr, $0.02 M_{\odot}$)
- Highly variable optical counterpart
- Very energetic pulsar
- *Black widow* type system
- Extremely steep spectrum
- No radio eclipses!?
- Too faint for LBA. . .



Summary and ongoing work

Summary:

- Discovery of a 707 Hz binary MSP with LOFAR!
- Extremely steep spectrum
- Counterpart identified; spin properties known with 40 days of timing
- LOFAR is ideally suited to find these steep spectrum MSPs (are all fast?)

Ongoing work:

- DDT for GBT 350 MHz to constrain spectrum/evolution of components
- *Swift* X-ray; possible NICER target
- Working on γ -ray timing (with AEI Hannover)
- **Write paper before LC8 deadline!**

Thank you!

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